IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Applicants: David Hartkop et al.

Examiner: Audrey. Y. Chang

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For: SCANNING APERTURE THREE DIMENSIONAL DISPLAY DEVICE

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APPEAL BRIEF

Applicants appeal the status of claims 1-52 and 57-81 as presented in response to the Office Action dated March 4, 2008, and finally rejected in the Office Action dated August 28, 2008 pursuant to the Notice of Appeal filed on November 25, 2008 and submit this appeal brief.

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C1. Because the Specification explicitly describes how a scanning aperture plate may be employed with a display screen or device to provide a three-dimensional image display, claims 1-52 and 57-81 comply with the enablement requirement.

C2. Because the Specification explicitly describes how multiple different perspectives of a scene may be simultaneously displayed such that different three-dimensional images may be viewable from different user-viewing angles, claims 1-52 and 57-81 comply with the enablement requirement.

C3. Claim 76 complies with the enablement requirement, as the formation of a hybrid screen is well known to those of ordinary skill in the art.

D. Whether Claims 1, 2, 5-18, 20, 21-23, 26-32, 34-41, 42-44, 46-52, 68-75 and 76-81 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs.

D1. Claims 1, 2, 5-18 and 20 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

D2. Claims 21-23, 26-32, 34-41 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

D3. Claims 42-44 and 46-52 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an LCD dynamic parallax barrier disposed in front of a display matrix.

D4. Claims 68-75 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

D5. Claims 76-81 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

E. Whether Claims 3, 4, 19, 24, 25, 33 and 45 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs in further view of Taniguchi.

E1. Claims 3, 4, 19, 24, 25, 33 and 45 are patentable over Just, Bacs and Taniguchi as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture device disposed in front of a display device.

F. Whether Claims 57-67 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs in further view of Taniguchi.

F1. Claims 57-67 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture device disposed in front of a display device.

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8. CLAIMS APPENDIX

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1. Real Party in Interest

The real parties in interest are David Hartkop and Jason Dunn.

2. Related Appeals and Interferences

None.

3. Status of Claims

Claims 1-52 and 57-81 are pending. Claims 53-56 are canceled without prejudice. Claims 1-52 and 57-81 stand rejected and are under appeal.

A copy of the claims 1-52 and 57-81 is presented in Section 8 below.

4. Status of Amendments

An Amendment under 37 CFR §1.111, mailed to the PTO on June 4, 2008 in response to the non-final Office Action dated March 4, 2008, was entered. A Response under 37 C.F.R. §1.116, sent to the PTO on October 27, 2008 in response to the final Office Action dated August 28, 2008, was also entered. No Responses/Amendments were filed subsequent to the above-referenced Response sent on October 27, 2008.

5. Summary of Claimed Subject Matter

Claim 1 is directed to a three dimensional display device (see, e.g., FIG. 1) including: a display screen (see, e.g., FIGS. 4 and 8, element 16) having pixels and a pixel width; an aperture plate (see, e.g., FIGS. 4 and 8, element 18) including apertures and opaque areas formed by closed

apertures between open apertures (see, e.g., FIGS. 12-13; and FIG. 15) that is disposed in front of said display screen (see, e.g., FIGS. 4 and 8); wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); and a gap (see, e.g., FIG. 4) separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm (see, e.g., p. 20, lines 13-16); wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene simultaneously viewable from respective multiple different user viewing angles (see, e.g., FIGS. 3, 4 and 8; p. 15, lines 3-8; and p. 17, lines 4-21).

Claim 21 is directed to a three dimensional display device (see, e.g., FIG. 1) including: a display screen (see, e.g., FIGS. 4 and 8, element 16) having pixels and a pixel width; an aperture plate (see, e.g., FIGS. 4 and8, element 18) including apertures and opaque areas formed by closed apertures between open apertures (see, e.g., FIGS. 12-13; and FIG. 15) that is disposed in front of said display screen (see, e.g., FIGS. 4 and 8); wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); and a distance (see, e.g., FIG. 4) separating said display screen and said aperture plate; wherein combined operation of the aperture plate and display screen generates a three dimensional display exhibiting both horizontal and vertical parallax (see, e.g., FIGS. 15, 18, and 19, p. 15, lines 3-12; p. 21, line 21 to p. 22, line 7; p. 23, line 9 to p. 26, line 8); wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an

open aperture (see, e.g., FIGS. 3, 4 and 8; p. 15, lines 3-8; and p. 17, lines 4-21).

Claim 42 is directed to a solid state three dimensional display device (see, e.g., FIG. 20, p. 27, lines 4-10) including: a display matrix (see, e.g., FIG. 20, element 44; p. 27, lines 8-10); a substrate (see, e.g., FIG. 20, element 42; p. 27, lines 8-9); and an LCD dynamic parallax barrier (see, e.g., FIG. 20, element 40; p. 27, line 8), including apertures and opaque areas formed by closed apertures between open apertures (see, e.g., FIG. 15; p. 28, lines 6-20), said display matrix and said LCD dynamic parallax barrier being bonded to opposing sides of said substrate (see, e.g., FIG. 20; p. 27, lines 14-16); wherein the LCD dynamic parallax barrier is configured such that the open apertures scan the LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); wherein the solid state three dimensional display device generates a three dimensional display exhibiting both horizontal and vertical parallax (see, e.g., p. 28, lines 14-16); wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open LCD dynamic parallax barrier opening (see, e.g., FIGS. 3, 4 and 8; p. 15, lines 3-8; and p. 17, lines 4-21).

Claim 57 is directed to a solid state three dimensional display device device (see, e.g., FIG. 20, p. 27, lines 4-10) including: a flat screen Ferroelectric LCD display matrix (see, e.g., FIG. 20, element 44; p. 27, lines 8-10; p. 7, lines 1-2); a substrate (see, e.g., FIG. 20, element 42; p. 27, lines 8-9); and a flat screen Ferroelectric LCD dynamic parallax barrier (see, e.g., FIG. 20, element 40; p. 27, line 8; p. 7, lines 2-3), including apertures and opaque areas formed by closed apertures between open apertures (see, e.g., FIG. 15; p. 28, lines 6-20), said display matrix and said FLCD dynamic

parallax barrier being bonded to opposing sides of said substrate (see, e.g., FIG. 20; p. 27, lines 14-16); wherein the flat screen Ferroelectric LCD dynamic parallax barrier is configured such that the open apertures scan the flat screen Ferroelectric LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); wherein the display device generates a three dimensional display exhibiting both horizontal and vertical parallax (see, e.g., p. 28, lines 14-16); wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open Ferroelectric LCD dynamic parallax barrier opening (see, e.g., FIGS. 3, 4 and 8; p. 15, lines 3-8; and p. 17, lines 4-21).

Claim 68 is directed to a three dimensional display device (see, e.g., FIG. 1) including: a flat screen display having pixels and a pixel width (see, e.g., FIGS. 4 and 8, element 16); a flat aperture plate (see, e.g., FIGS. 4 and 8, element 18) including apertures and opaque areas formed by closed apertures between open apertures (see, e.g., FIGS. 12-13; and FIG. 15) that is disposed in front of said display screen (see, e.g., FIGS. 4 and 8); wherein the flat aperture plate is configured such that the open apertures scan the flat aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); and a gap (see, e.g., FIG. 4) separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm (see, e.g., p. 20, lines 13-16); wherein the three dimensional display provides multiple different perspectives of a scene which are simultaneously viewable from multiple different user viewing angles with respect to an open aperture (see, e.g., FIGS. 3, 4 and 8; p. 15, lines 3-8; and p. 17, lines 4-21).

Claim 76 is directed to a three dimensional display device including: a hybrid screen display (see, e.g., p. 20, lines 17-22) having pixels and a pixel width (see, e.g., FIGS. 4 and 8, element 16); a flat aperture plate (see, e.g., FIGS. 4 and 8, element 18) including apertures and opaque areas formed by closed apertures between open apertures (see, e.g., FIGS. 12-13; and FIG. 15) that is disposed in front of said display screen (see, e.g., FIGS. 4 and 8); wherein the flat aperture plate is configured such that the open apertures scan the flat aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent (see, e.g., FIG. 15, p. 25, lines 5-11; p. 13, lines 5-21); and a gap (see, e.g., FIG. 4) separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm (see, e.g., p. 20, lines 13-16); wherein the three dimensional display simultaneously provides multiple different viewable perspectives of a scene based on horizontal and vertical viewing angles with respect to an open aperture (see, e.g., FIGS. 3, 4, 8, 15, 18 and 19; p. 15, lines 3-12; and p. 17, lines 4-21; p. 21, line 21 to p. 22, line 7; p. 23, line 9 to p. 26, line 8).

6. <u>Grounds of Rejection to be Reviewed on Appeal</u>

Claims 1-52 and 57-81 stand rejected under 35 U.S.C. §112, first paragraph for purportedly failing to comply with the written description requirement.

Claims 1-52 and 57-81 stand rejected under 35 U.S.C. §112, first paragraph for purportedly failing to comply with the enablement requirement.

Claims 1-2, 5-18, 20, 21-23, 26-32, 34-41, 42-44, 46-52, 68-75 and 76-81 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,6,74,463 to Just et al. (hereinafter 'Just') in view of U.S. Patent No. 5,678,089 to Bacs Jr. et al. (hereinafter 'Bacs').

Claims 3, 4, 19, 24, 25, 33 and 45 stand rejected under 35 U.S.C. 103(a) as being

unpatentable over Just in view of Bacs in further view of U.S. Patent No. 6,094,216 to Taniguchi et al. (hereinafter 'Taniguchi').

Claims 57-67 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Just in view of Bacs in further view of Taniguchi.

The preceding rejections are presented for review in this Appeal.

Regarding the grouping of the claims, due to their respective dependencies, claims 2-20 stand or fall with claim 1, claims 22-41 stand or fall with claim 21, claims 43-52 stand or fall with claim 42, claims 58-67 stand or fall with claim 57, claims 69-75 stand or fall with claim 68 and claims 77-81 stand or fall with claim 76.

7. <u>Argument</u>

A. Introduction

In general, the present principles are directed to a scanning aperture three-dimensional display device that provides many different perspectives of a scene to a user. Accordingly to one exemplary aspect, a realistic view of a scene may be provided by presenting over one thousand perspectives so that any small variation in a user's head orientation in any direction permits the user to see a new and different three-dimensional image (see, e.g., Specification, p. 23, lines 20-22; p. 17, lines 12-16). A large number of perspectives may be presented in both the vertical and horizontal directions by employing scanning apertures over a display that move in two dimensions at a rate that is above a human persistence of vision threshold, which is sufficient to generate an illusion that an aperture plate or device is transparent (see, e.g., FIG. 15, p. 13, lines 5-21; p. 15, lines 3-12; and p. 25, lines 5-11).

As discussed herein below, the Specification fully supports aperture scanning in two-dimensional movements. In addition, the Specification provides sufficient detail to enable one skilled in the art to make and use a scanning aperture plate or device with a display device to generate three-dimensional images that are simultaneously viewable from multiple different user viewing angles. Furthermore, the references cited by the Examiner do not render obvious scanning open apertures in two-dimensional movements to generate an illusion that opaque areas of the aperture device are transparent, as recited in the independent claims.

Accordingly, it is respectfully submitted that the independent claims of the present application are patentable over the rejections and the cited art. As such, the independent claims are presented for review in this appeal.

B. Whether Claims 1-52 and Claims 57-81 Comply with the Written Description Requirement under 35 U.S.C. §112, first paragraph.

B1. <u>Claims 1-52 and Claims 57-81 comply with the written description requirement under 35 U.S.C. §112, first paragraph, as the Specification adequately describes scanning an aperture plate or device with open apertures in two-dimensional movements</u>.

Because the Specification describes open apertures scanning an aperture plate or device in two-dimensional movements in sufficient detail that one skilled in the art can reasonably conclude that the inventors had possession of the claimed invention, claims 1-52 and claims 57-81 comply with the written description requirement. "To satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention." MPEP §2163(I)

(citing Moba, B.V. v. Diamond Automation, Inc., 325 F.3d 1306, 1319 (Fed. Cir. 2003)).

In support of the rejection of claims 1-52 and claims 57-81, the Examiner has alleged that the feature of "open apertures scan the aperture plate in two-dimensional movements," as recited in various independent claims, is not supported by the original disclosure (see Final Office Action, p. 2-3, sections 1 and 3). However, Figure 15 of the Specification illustrates that open apertures are scanned over a two-dimensional region (see also Specification, p. 25, lines 5-11). Furthermore, the Specification states that the scanning pattern may, for example, be "stair stepped," also illustrating that two-dimensional movements of open apertures is supported in the Specification (see, e.g., Specification, p. 24, line 15 and p. 25, lines 9-10).

Accordingly, the Specification adequately describes scanning an aperture plate or device with open apertures in two-dimensional movements in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention. As such, claims 1-52 and claims 57-81 comply with the written description requirement. Withdrawal of the rejection is respectfully requested.

C. Whether Claims 1-52 and Claims 57-81 Comply with the Enablement Requirement under 35 U.S.C. §112, first paragraph.

Claims 1-52 and 57-81 comply with the enablement requirement under 35 U.S.C. §112, first paragraph, as the Specification provides sufficient information to make and use the claimed inventions without undue experimentation. In support of the rejections of the claims, the Examiner has purported that the Specification does not teach: a) how simply having an aperture plate with apertures scanning the plate is capable of providing a three-dimensional image display;

b) that multiple different perspectives form perceived 3D images simultaneously viewable from respective multiple different user viewing angles; and c) how a hybrid screen is formed (see Final Office Action, p. 3, section 4).

First, as discussed herein below, claims 1-52 and 57-81 comply with the enablement requirement because the Specification explicitly teaches that an aperture plate may be employed with a display screen or device to provide different perspectives of a scene to each eye of a user while blocking from each eye a view of other displayed perspectives and thereby form a three-dimensional image display. Second, claims 1-52 and 57-81 comply with the enablement requirement because the Specification explicitly teaches how multiple different perspectives of a scene may be simultaneously displayed such that different three-dimensional images may be viewable from different user-viewing angles. Third, claim 76 complies with the enablement requirement, as the formation of a "hybrid screen" is well known to those of skill in the art. Accordingly, for at least the reasons discussed herein below, the withdrawal rejection of claims 1-52 and 57-81 under 35 U.S.C. §112, first paragraph is respectfully requested.

C1. <u>Because the Specification explicitly describes how a scanning aperture plate may be employed with a display screen or device to provide a three-dimensional image display, claims 1-52 and 57-81 comply with the enablement requirement</u>.

Claims 1-52 and 57-81 comply with the enablement requirement, as the Specification explicitly teaches that an aperture plate may be used to present a three-dimensional image display by providing different perspectives of a scene shown on a display screen or device to each eye of a user while blocking other perspectives displayed on the screen or device. The enablement

requirement is satisfied when the Specification includes sufficient information regarding the subject matter of the claims as to enable one skilled in the pertinent art to make and use the claimed invention without undue experimentation. MPEP §2164.01 (citing Mineral Separation v. Hyde, 242 U.S. 261, 270 (1916) and In re Wands, 858 F.2d 731, 737 (Fed. Cir. 1988)). Furthermore, a "patent need not teach, and preferably omits, what is well known in the art." Id. (citing In re Buchner, 929 F.2d 660, 661 (Fed. Cir. 1991)).

Utilizing a display screen or display device and an aperture plate or aperture device to generate three-dimensional images, as recited in the various independent claims of the present application, is enabled by the Specification. The Specification teaches that a three-dimensional image may be formed by providing "discreet viewing angles" or different perspectives of a scene to each eye of a user (see, e.g., Specification, FIG. 4; p. 17, lines 12-14; and p. 15, lines 3-6). The Specification also teaches that a display screen or device may be used to display different two-dimensional image perspectives of a scene (see, e.g., Specification, FIG. 6; p. 13, lines 16-18) and that an aperture plate or device may be employed over the display to provide different perspectives to each eye while blocking other perspectives to present a three-dimensional image (see, e.g., Specification, FIGS. 4 and 6; p. 17, lines 12-19; p. 11, lines 3-5). Moreover, the Specification also describes an aperture plate or device with open apertures that scan the plate or device with a rapidly changing display screen or display device that presents images in synchronization with the scanning apertures so that the number of different perspectives displayed is maximized, thereby permitting a realistic three-dimensional display that changes with any slight movement of a user (see, e.g., Specification, FIGS. 6 and 8; p. 13, lines 5-21; p. 17, lines 1-21). The Specification further notes that image information for the display of 2-

dimensional perspectives may be extracted from three-dimensional codec files, such as DXF files, for example (see, e.g., Specification, p. 21, lines 12-17).

Accordingly, the Specification includes sufficient information to enable one skilled in the pertinent art to make and use a display screen or display device and an aperture plate or aperture device to generate three-dimensional images, as recited in the various independent claims of the present application. As such, withdrawal of the rejection of claims 1-52 and 57-81 is respectfully requested.

C2. Because the Specification explicitly describes how multiple different perspectives of a scene may be simultaneously displayed such that different three-dimensional images may be viewable from different user-viewing angles, claims 1-52 and 57-81 comply with the enablement requirement.

Claims 1-52 and 57-81 comply with the enablement requirement, as the Specification teaches that different three-dimensional images may be viewable from different user angles by simultaneously displaying multiple, different perspectives of a scene through an aperture plate or device. The enablement requirement is satisfied when the Specification includes sufficient information regarding the subject matter of the claims as to enable one skilled in the pertinent art to make and use the claimed invention without undue experimentation. MPEP §2164.01 (citing Mineral Separation v. Hyde, 242 U.S. 261, 270 (1916) and In re Wands, 858 F.2d 731, 737 (Fed. Cir. 1988)). Furthermore, a "patent need not teach, and preferably omits, what is well known in the art." Id. (citing In re Buchner, 929 F.2d 660, 661 (Fed. Cir. 1991)).

Providing multiple different perspectives of a scene that form perceived 3D images of the

scene which are simultaneously viewable from respective multiple different user angles, as recited in some of the independent claims of the present application, is enabled by the Specification. As stated above, the Specification teaches that a three-dimensional image may be formed by providing "discreet viewing angles" or different perspectives of a scene to each eye of a user (see, e.g., Specification, FIG. 4; p. 17, lines 12-14; and p. 15, lines 3-6). As discussed above, the Specification teaches that the three-dimensional display may be generated by providing different two-dimensional images corresponding to different perspectives of a scene on the display screen or device and employing the aperture plate or device to transmit different perspectives to each eye of a user while blocking other displayed perspectives (see, e.g., Specification, FIG. 6; p. 13, lines 16-18; FIG. 4; p. 17, lines 12-19; and p. 11, lines 3-5). In addition, the Specification further indicates that multiple perspectives may be simultaneously displayed on a display screen or device and through an aperture plate or device (see FIG. 4) such that movement of a user's head to different viewing angles permits the a user to view new and different perspectives of a scene corresponding to different, simultaneously viewable three-dimensional images (see, e.g., Specification, p. 17, lines 12-19).

Accordingly, the Specification includes sufficient information to enable one skilled in the pertinent art to make and use a display screen or display device and an aperture plate or aperture device to provide multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user angles. As such, withdrawal of the rejection is respectfully requested.

C3. Claim 76 complies with the enablement requirement, as the formation of a hybrid screen is well known to those of ordinary skill in the art.

Because the formation of a hybrid screen is well known to those of ordinary skill in the art, claim 76 complies with the enablement requirement. The enablement requirement is satisfied when the Specification includes sufficient information regarding the subject matter of the claims as to enable one skilled in the pertinent art to make and use the claimed invention without undue experimentation. MPEP §2164.01 (citing Mineral Separation v. Hyde, 242 U.S. 261, 270 (1916) and In re Wands, 858 F.2d 731, 737 (Fed. Cir. 1988)). Furthermore, a "patent need not teach, and preferably omits, what is well known in the art." Id. (citing In re Buchner, 929 F.2d 660, 661 (Fed. Cir. 1991)).

The Specification describes a hybrid display as utilizing a combination of a variety of display technologies, such as High-speed liquid crystal display technology or Ferroelectric liquid crystal display (FLCD); Organic LED technology; Miniature LED technology, plasma, zero twist nematic LC; and/or rear projections using multiple projectors or a DLP mirror chip, for example (see Specification, p. 20, lines 17-22). One example of a hybrid screen is described in the Abstract of Exhibit A, U.S. Patent No. 5,790,217 to Lee et al. (1998), which demonstrates that FLCD hybrids are well known in the art. Thus, claim 76 complies with the enablement requirement at least because the formation of a hybrid screen is well known in the art. Accordingly, withdrawal of the rejection is respectfully requested.

D. Whether Claims 1, 2, 5-18, 20, 21-23, 26-32, 34-41, 42-44, 46-52, 68-75 and 76-81 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs.

D1. Claims 1, 2, 5-18 and 20 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

Because Just and Bacs, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display screen in two-dimensional movements to generate three-dimensional images, claims 1, 2, 5-18 and 20 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 1 recites:

> A three dimensional display device comprising:
>
> a display screen having pixels and a pixel width;
>
> an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;
>
> wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and
>
> a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;
>
> wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene simultaneously viewable from respective multiple different user viewing angles.

(emphasis added).

Just and Bacs fail to disclose or render obvious an aperture plate that is configured such that open apertures scan an aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent. Although Just describes employing scanning apertures over a display to generate three-dimensional images, the scanning apertures disclosed by Just move in a single dimension (see, e.g., Just, FIGS. 7A and 7B, illustrating scanning apertures that move in one-dimension from left to right). Nowhere does Just disclose or remotely suggest apertures that scan in two-dimensional movements.

In support of the rejection, the Examiner has stated that "Just teaches that it is a straight-forward modification to generalize the horizontal parallax case to arbitrary observation positions" (see, e.g., Final Office Action dated August 28, 2008, p. 7, para. 1 (citing Just, column 7, lines 1-4)). Further, the Examiner has interpreted Just's statement as meaning that "the single aperture technique can be modified and generalized to provide for instance full parallax, i.e. also includes vertical parallax for allowing more positions for observation positions." (see Final Office Action dated August 28, 2008, p. 7, para. 1). However, the Examiner has applied improper hindsight of the present principles in interpreting Just. Although Just mentions that the horizontal parallax case may be generalized to arbitrary observation positions, Just was referring to other single-dimension parallax lines, such as vertical or diagonal parallax. In the very next clause, Just states that the generalization to other observation positions is "hardly relevant in practice since the eyes of a human observer are arranged horizontally," as opposed to vertically or diagonally, for example. (see Just, column 7, line 3-5). Accordingly, Just merely suggests, and incidentally, explicitly dismisses in practice, that other one-dimensional scanning patterns corresponding to other observer parallax lines

may be employed. Just nowhere discloses, remotely suggests or renders obvious generating three-dimensional images by using a two-dimensional scanning pattern over a screen, which enables the simultaneous display of both vertical and horizontal parallax to provide a more realistic three-dimensional scene that appears to change when a user changes her viewing angle in any direction.

Furthermore, Bacs fails to cure the deficiencies of Just, as Bacs is directed to a completely different method for displaying a three dimension image. Just teaches applying apertures over a screen to generate a 3D image by presenting a different perspective of an object to each eye of a user. In contrast, the display device utilized by Bacs does not employ any apertures whatsoever over a display screen to generate a three-dimensional image. Rather, Bacs is directed to a parallax scanning method, which sequentially presents frames recorded from different viewing angles of a scene at a rapid rate on a conventional display screen without any other viewing devices, such as an aperture plate (a type of parallax barrier) (see, e.g., Bacs, Abstract, lines 1-8; Title; column 1, lines 51-62; column 3, lines 51-59; column 9, lines 26-42). Moreover, the scanning pattern taught by Bacs is applied to a moving aperture (30) disposed in front of a camera lens (24) during recording of frames from different viewing angles (see, e.g., Bacs, FIG. 1; column 5, lines 34-37; column 5, lines 52-58; column 5, lines 61-64; column 3, lines 36-46; column 9, lines 26-42). The manner in which different viewing angles are recorded for use in a parallax scanning 3D display, which does not in any way employ apertures during presentation of three-dimensional images to a user, has no bearing whatsoever on a scanning aperture pattern used over a display device to present different perspectives to each eye of a user, as taught in Just.

Accordingly, in view of Bacs and Just, it would not be obvious to utilize an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-

dimensional movements to generate three-dimensional images and to generate an illusion that opaque areas are transparent, as recited in claim 1. Therefore, claim 1 is patentable over Just and Bacs, taken singly or in combination. Moreover, claims 2, 5-18 and 20 are patentable over Just and Bacs due at least to their dependencies on claim 1. As such, withdrawal of the rejection is respectfully requested.

D2. Claims 21-23, 26-32, 34-41 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

Because Just and Bacs, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display screen in two-dimensional movements to generate three-dimensional images, claims 21-23, 26-32, 34-41 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 21 recites:

> A three dimensional display device comprising:
>
> a display screen having pixels and a pixel width;
>
> an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;
>
> wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a distance separating said display screen and said aperture plate;

wherein combined operation of the aperture plate and display screen generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that <u>form perceived 3D images</u> of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open aperture.

(emphasis added).

As discussed above with regard to claim 1, Just and Bacs, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 21 is patentable over Just and Bacs. Moreover, claims 22, 23, 26-32, 34-41 are patentable over Just and Bacs due at least to their dependencies on claim 21. As such, withdrawal of the rejection is respectfully requested.

D3. <u>Claims 42-44 and 46-52 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an LCD dynamic parallax barrier disposed in front of a display matrix</u>.

Because Just and Bacs, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display matrix in two-dimensional movements to generate three-dimensional images, claims 21-23, 26-32 and 34-41 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person

having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 42 recites:

> A solid state three dimensional display device comprising:
>
> a display matrix;
>
> a substrate; and
>
> an LCD dynamic parallax barrier, including apertures and opaque areas formed by closed apertures between open apertures, said display matrix and said LCD dynamic parallax barrier being bonded to opposing sides of said substrate;
>
> wherein the LCD dynamic parallax barrier is configured such that the open apertures scan the LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent;
>
> wherein the solid state three dimensional display device generates a three dimensional display exhibiting both horizontal and vertical parallax;
>
> wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open LCD dynamic parallax barrier opening.

(emphasis added).

As discussed above with regard to claim 1, Just and Bacs, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Similarly, Just and Bacs, fail to disclose or render obvious utilizing an LCD dynamic parallax barrier over a display matrix that is configured such that open apertures scan the parallax barrier in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 42 is patentable over Just and Bacs. Additionally, claims 43, 44, and 46-52 are

patentable over Just and Bacs due at least to their dependencies on claim 42. As such, withdrawal of the rejection is respectfully requested.

D4. Claims 68-75 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen.

Because Just and Bacs, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display screen in two-dimensional movements to generate three-dimensional images, claims 68-75 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 68 recites:

> A three dimensional display device comprising:
>
> a flat screen display having pixels and a pixel width;
>
> a flat aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;
>
> wherein the flat aperture plate is configured such that the open apertures scan the flat aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and
>
> a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;
>
> wherein the three dimensional display provides multiple different perspectives of a scene which are simultaneously viewable from multiple different user viewing angles

with respect to an open aperture.

(emphasis added).

As discussed above with regard to claim 1, Just and Bacs, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 68 is patentable over Just and Bacs. Moreover, claims 69-75 are patentable over Just and Bacs due at least to their dependencies on claim 68. As such, withdrawal of the rejection is respectfully requested.

D5. <u>Claims 76-81 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture plate disposed in front of a display screen</u>.

Because Just and Bacs, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display screen in two-dimensional movements to generate three-dimensional images, claims 76-81 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." <u>KSR International Co. v. Teleflex, Inc.</u>, 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 76 recites:

> A three dimensional display device comprising:
> a hybrid screen display having pixels and a pixel width;
> a flat <u>aperture plate</u> including apertures and opaque areas formed by closed

apertures between open apertures that is disposed in front of said display screen;

wherein the flat aperture plate is configured such that the open apertures scan the flat aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;

wherein the three dimensional display simultaneously provides multiple different viewable perspectives of a scene based on horizontal and vertical viewing angles with respect to an open aperture.

(emphasis added).

As discussed above with regard to claim 1, Just and Bacs, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 76 is patentable over Just and Bacs. Moreover, claims 77-81 are patentable over Just and Bacs due at least to their dependencies on claim 68. As such, withdrawal of the rejection is respectfully requested.

E. Whether Claims 3, 4, 19, 24, 25, 33 and 45 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs in further view of Taniguchi.

E1. Claims 3, 4, 19, 24, 25, 33 and 45 are patentable over Just, Bacs and Taniguchi as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture device disposed in front of a display device.

Because Just, Bacs and Taniguchi, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display device in two-dimensional

movements to generate three-dimensional images, claims 3, 4, 19, 24, 25, 33 and 45 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)).

Claims 3, 4 and 19 are dependent on claim 1. Accordingly, claims 3, 4 and 19 include:

> a display screen having pixels and a pixel width;
>
> an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;
>
> wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and
>
> a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;
>
> wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene simultaneously viewable from respective multiple different user viewing angles.

(emphasis added).

Claims 24, 25 and 33 depend on claim 21. Accordingly, claims 24, 25 and 33 include:

> a display screen having pixels and a pixel width;
>
> an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;
>
> wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a distance separating said display screen and said aperture plate;

wherein combined operation of the aperture plate and display screen generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open aperture. (emphasis added).

As discussed above, Just and Bacs, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan an aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Furthermore, Taniguchi fails to cure the deficiencies of Just and Bacs.

Taniguchi does not disclose or render obvious scanning a display with open apertures in two-dimensional movements, nor does it disclose or render suggest scanning a display with open apertures to generate an illusion that opaque areas of the display are transparent. As illustrated in FIG. 4B, for example, Taniguchi simply discloses moving apertures to the left or the right in one-dimension. Taniguchi fails to disclose open apertures that scan a display in two-dimensional movements. Accordingly, Taniguchi does not cure the deficiencies of Just and/or Bacs.

Therefore, claims 3, 4, 19, 24, 25 and 33 are patentable over Just, Bacs and Taniguchi, taken singly or in any combination, due at least to their dependencies on claims 1 and 21.

With regard to claim 44, claim 44 is dependent on claim 42. Thus, claim 44 includes:

a display matrix;

a substrate; and

an LCD dynamic parallax barrier, including apertures and opaque areas formed by

closed apertures between open apertures, said display matrix and said LCD dynamic parallax barrier being bonded to opposing sides of said substrate;

wherein the LCD dynamic parallax barrier is configured such that the open apertures scan the LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent;

wherein the solid state three dimensional display device generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open LCD dynamic parallax barrier opening.

(emphasis added.

As discussed above, Just, Bacs and/or Taniguchi fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Similarly, Just, Bacs and/or Taniguchi fail to disclose or render obvious utilizing an LCD dynamic parallax barrier over a display matrix that is configured such that open apertures scan the parallax barrier in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 44 is patentable over Just, Bacs and/or Taniguchi due at least to its dependency on claim 42. As such, withdrawal of the rejection is respectfully requested.

F. Whether Claims 57-67 are Unpatentable under 35 U.S.C. 103(a) over Just in View of Bacs in further view of Taniguchi.

F1. Claims 57-67 are patentable over Just in view of Bacs, as the references fail to disclose or render obvious at least the feature of scanning open apertures in two-dimensional movements over an aperture device disposed in front of a display device.

Because Just, Bacs and Taniguchi, taken singly or in combination, do not disclose or render obvious the feature of scanning open apertures over a display device in two-dimensional movements to generate three-dimensional images, claims 57-67 are patentable over the cited references. Claimed subject matter is unpatentable under 35 U.S.C. 103(a) "if the differences between the subject matter sought to be protected and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." KSR International Co. v. Teleflex, Inc., 127 S.Ct.1727, 1734 (quoting 35 U.S.C. 103(a)). Claim 57 recites:

> A solid state three dimensional display device comprising:
>
> a flat screen Ferroelectric LCD display matrix;
>
> a substrate; and
>
> a flat screen Ferroelectric LCD dynamic parallax barrier, including apertures and opaque areas formed by closed apertures between open apertures, said display matrix and said FLCD dynamic parallax barrier being bonded to opposing sides of said substrate;
>
> wherein the flat screen Ferroelectric LCD dynamic parallax barrier is configured such that the open apertures scan the flat screen Ferroelectric LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent;
>
> wherein the display device generates a three dimensional display exhibiting both horizontal and vertical parallax;
>
> wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously

viewable from respective multiple different user viewing angles with respect to an open Ferroelectric LCD dynamic parallax barrier opening.

(emphasis added)

As discussed above, Just, Bacs and Taniguchi, taken singly or in combination, fail to disclose or render obvious utilizing an aperture plate over a display screen that is configured such that open apertures scan the aperture plate in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Similarly, Just, Bacs and/or Taniguchi fail to disclose or render obvious utilizing flat screen Ferroelectric LCD dynamic parallax barrier over a flat screen Ferroelectric LCD display matrix that is configured such that open apertures scan the parallax barrier in two-dimensional movements to generate an illusion that opaque areas are transparent and to generate three-dimensional images. Thus, claim 57 is patentable over Just, Bacs and/or Taniguchi. Additionally, claims 58-67 are patentable over Just, Bacs and Taniguchi due at least to their dependencies on claim 57. As such, withdrawal of the rejection is respectfully requested.

G. Conclusion

As discussed above, the features of the pending claims comply with both the written description requirement and the enablement requirement of 35 U.S.C. §112, first paragraph. Furthermore, as discussed above, the cited references fail to render the pending claims unpatentable under 35 U.S.C. §103(a). Accordingly, it is respectfully requested that the Board reverse the rejections of claims 1-52 and 57-81 under 35 U.S.C. §112, first paragraph and 35 U.S.C. §103(a).

Please charge the amount of $270.00, covering the fee associated with the filing of the Appeal Brief, to the applicants' representatives **Deposit Account No. 50-1433.** It is believed that no additional fees or charges are currently due. However, in the event that any additional fees or charges are required at this time in connection with the application, they may be charged to applicant's representatives Deposit Account No. 50-1433.

Respectfully submitted,

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8. CLAIMS APPENDIX

1. (Previously presented) A three dimensional display device comprising:

a display screen having pixels and a pixel width;

an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;

wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene simultaneously viewable from respective multiple different user viewing angles.

2. (Previously presented) The three dimensional display device according to claim 1, further comprising a control system connected to said display screen and said aperture plate, said control system controlling sequencing of image portions on said display screen and controlling sequencing of predetermined apertures of said aperture plate to produce three-dimensional images.

3. (Original) The three dimensional display device according to claim 1, wherein said gap comprises an air gap between said display screen and said aperture plate.

4. (Original) The three dimensional display device according to claim 1, wherein said gap comprises a solid substrate between said display screen and said aperture plate.

5. (Previously presented) The three dimensional display device according to claim 1, wherein said aperture plate is capable of producing vertical slit aperture openings having a slit width.

6. (Original) The three dimensional display device according to claim 5, wherein said slit width is equal to said pixel width.

7. (Original) The three dimensional display device according to claim 5, wherein said slit width is wider than said pixel width.

8. (Original) The three dimensional display device according to claim 1, wherein said aperture plate includes a predetermined number of apertures, said predetermined number of apertures being less than a number of pixels on the display screen.

9. (Previously presented) The three dimensional display device according to claim 1, wherein said aperture plate includes a predetermined number of active regions configured to form open apertures and opaque areas in accordance with an aperture scanning operation, said predetermined number of active regions being equal to a number of pixels on the display screen.

10. (Original) The three dimensional display device according to claim 1, wherein said

display comprises a high frame rate video display device having frame rates exceeding 150 frames per second.

11. (Previously presented) The three dimensional display device according to claim 1, wherein said display comprises a high frame rate video display device having a frame rate, wherein said display has a resolution capable of producing at least 8 different perspectives, each different perspective viewable from a different viewing angle.

12. (Previously Presented) The three dimensional display device according to claim 11, wherein said frame rate comprises at least 150 frames per second.

13. (Original) The three dimensional display device according to claim 1, wherein said aperture plate comprises a high speed optical shuttering system.

14. (Original) The three dimensional display device according to claim 10, wherein said display is a direct display and is one selected from a group consisting of Liquid Crystal Display (LCD), Ferroelectric LCD (FLCD), Organic LED (OLED) and Plasma displays.

15. (Original) The three dimensional display device according to claim 10, wherein said display is a rear projection display device.

16. (Previously presented)The three dimensional display device according to claim 15,

wherein said display is one selected from a group consisting of a high speed projector and a Digital Light Processing (DLP) projection system.

17. (Previously presented) The three dimensional display device according to claim 7, wherein said aperture plate comprises a solid state scan type aperture plate.

18. (Previously presented) The three dimensional display device according to claim 17, wherein said solid state scan type aperture plate comprises one selected from a group consisting of flat scanners and curved scanners.

19. (Original) The three dimensional display device according to claim 1, wherein said display device comprises a Ferroelectric LCD (FLCD).

20. (Original) The three dimensional display device according to claim 1, wherein said aperture plate comprises a Ferroelectric LCD (FLCD).

21. (Previously presented) A three dimensional display device comprising:

a display screen having pixels and a pixel width;

an aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;

wherein the aperture plate is configured such that the open apertures scan the aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent;

and

a distance separating said display screen and said aperture plate;

wherein combined operation of the aperture plate and display screen generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open aperture.

22. (Original) The three dimensional display device according to claim 21, wherein said apertures have a size not smaller than a size of said pixels.

23. (Original) The three dimensional display device according to claim 21, wherein said distance is within a range of 0.1cm – 5cm.

24. (Original) The three dimensional display device according to claim 21, wherein said distance separating said display screen from said aperture plate comprises an air gap.

25. (Original) The three dimensional display device according to claim 21, wherein said distance separating said display screen from said aperture plate comprises a solid substrate.

26. (Original) The three dimensional display device according to claim 21, wherein said display screen is dimensionally larger than said aperture plate.

27. (Previously presented) The three dimensional display device according to claim 21, wherein at least one of the perceived 3D images comprises a horizontal view angle range of at least 10 – 30 degrees from normal.

28. (Original) The three dimensional display device according to claim 21, wherein said horizontal parallax has a viewable operating range up to 180 degrees.

29. (Previously presented) The three dimensional display device according to claim 21, wherein the 3D image displayed comprises a vertical view angle range comprises 5 – 25 degrees from normal.

30. (Original) The three dimensional display device according to claim 21, wherein said vertical parallax has a viewable operating range up to 180 degrees.

31. (Previously presented) The three dimensional display device according to claim 21, wherein said display screen comprises a high frame rate video display device.

32. (Previously presented) The three dimensional display device according to claim 31, wherein said display screen comprises a frame rate exceeding 150 frames per second.

33. (Previously presented) The three dimensional display device according to claim 31,

wherein said display screen comprises a Ferroelectric LCD (FLCD) device.

34. (Original) The three dimensional display device according to claim 21, wherein said aperture plate comprises a high speed optical shuttering system.

35. (Previously presented) The three dimensional display device according to claim 21, wherein said display screen is one selected from a group consisting of LCD, Ferroelectric LCD, Organic LED (OLED) and Plasma displays.

36. (Previously presented) The three dimensional display device according to claim 21, wherein said display screen is a rear projection display device.

37. (Previously presented) The three dimensional display device according to claim 36, wherein said display screen is one selected from a group consisting of a high speed projector and a DLP.

38. (Previously presented) The three dimensional display device according to claim 32, wherein said aperture plate comprises a solid state scan type.

39. (Previously presented) The three dimensional display device according to claim 38, wherein said solid state scan type comprises one selected from a group consisting of flat and curved scanners.

40. (Original) The three dimensional display device according to claim 34, wherein said aperture plate comprises a Ferroelectric LCD device.

41. (Original) The three dimensional display device according to claim 21, wherein a number of vertical viewing angles is less than a number of horizontal viewing angles.

42. (Previously presented) A solid state three dimensional display device comprising:

a display matrix;

a substrate; and

an LCD dynamic parallax barrier, including apertures and opaque areas formed by closed apertures between open apertures, said display matrix and said LCD dynamic parallax barrier being bonded to opposing sides of said substrate;

wherein the LCD dynamic parallax barrier is configured such that the open apertures scan the LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent;

wherein the solid state three dimensional display device generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open LCD dynamic parallax barrier opening.

43. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said substrate has a thickness in a range of 0.1cm – 5cm.

44. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said display matrix comprises pixels, said apertures having a size not smaller than a size of said pixels.

45. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said display matrix comprises a color FLCD device.

46. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said LCD dynamic parallax barrier comprises a FLCD device.

47. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said display matrix comprises a display having a frame rate exceeding 150 frames per second.

48. (Previously presented) The solid state three dimensional display device according to claim 47, wherein said display matrix comprises a display having a frame rate no greater than 20,000 frames per second.

49. (Previously presented) The solid state three dimensional display device according to claim 42, wherein the horizontal parallax comprises a horizontal view angle range of 20 – 60 degrees.

50. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said horizontal parallax has a viewable operating range up to 180 degrees.

51. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said vertical parallax comprises a vertical view angle range of 10 – 50 degrees.

52. (Previously presented) The solid state three dimensional display device according to claim 42, wherein said vertical parallax has a viewable operating range up to 180 degrees.

53. (Canceled).

54. (Canceled).

55. (Canceled).

56. (Canceled).

57. (Previously presented) A solid state three dimensional display device comprising:

a flat screen Ferroelectric LCD display matrix;

a substrate; and

a flat screen Ferroelectric LCD dynamic parallax barrier, including apertures and opaque areas formed by closed apertures between open apertures, said display matrix and said FLCD dynamic parallax barrier being bonded to opposing sides of said substrate;

wherein the flat screen Ferroelectric LCD dynamic parallax barrier is configured such that the open apertures scan the flat screen Ferroelectric LCD dynamic parallax barrier in two-dimensional movements to generate an illusion that the opaque areas are transparent;

wherein the display device generates a three dimensional display exhibiting both horizontal and vertical parallax;

wherein the three dimensional display provides multiple different perspectives of a scene that form perceived 3D images of the scene which are simultaneously viewable from respective multiple different user viewing angles with respect to an open Ferroelectric LCD dynamic parallax barrier opening.

58. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said substrate has a thickness in a range of 0.1cm – 5cm.

59. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said display matrix comprises pixels, said apertures having a size not smaller than a size of said pixels.

60. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said display matrix comprises a color FLCD device.

61. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said LCD dynamic parallax barrier comprises a FLCD device.

62. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said display matrix comprises a display having a frame rate exceeding 150 frames per second.

63. (Previously presented) The solid state three dimensional display device according to claim 62, wherein said display matrix comprises a display having a frame rate no greater than 20,000 frames per second.

64. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said horizontal parallax comprises a horizontal view angle range of 20 – 60 degrees.

65. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said horizontal parallax has a viewable operating range up to 180 degrees.

66. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said vertical parallax comprises a vertical view angle range of 10 – 50 degrees.

67. (Previously presented) The solid state three dimensional display device according to claim 57, wherein said vertical parallax has a viewable operating range up to 180 degrees.

68. (Previously presented) A three dimensional display device comprising:

a flat screen display having pixels and a pixel width;

a flat aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;

wherein the flat aperture plate is configured such that the open apertures scan the flat aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;

wherein the three dimensional display provides multiple different perspectives of a scene which are simultaneously viewable from multiple different user viewing angles with respect to an open aperture.

69. (Original) The three dimensional display device according to claim 68, wherein said flat screen display and said flat aperture plate comprise a Ferroelectric LCD device.

70. (Original) The three dimensional display device according to claim 68, wherein said flat screen display and said flat aperture plate have frame rates exceeding 150 frames per second.

71. (Previously presented) The three dimensional display device according to claim 70, wherein said flat screen display comprises a display having a frame rate no greater than 20,000 frames per second.

72. (Previously presented) The three dimensional display device according to claim 68, wherein the multiple different user viewing angles comprise a horizontal view angle range of 20 – 60 degrees.

73. (Previously presented) The three dimensional display device according to claim 68, wherein the multiple different user viewing angles comprise a horizontal viewable operating range up to 180 degrees.

74. (Previously presented) The three dimensional display device according to claim 68, wherein the multiple different user viewing angles comprise a vertical view angle range of 10 – 50 degrees.

75. (Previously presented) The three dimensional display device according to claim 68, wherein the multiple different user viewing angles comprises a vertical viewable operating range up to 180 degrees.

76. (Previously presented) A three dimensional display device comprising:

a hybrid screen display having pixels and a pixel width;

a flat aperture plate including apertures and opaque areas formed by closed apertures between open apertures that is disposed in front of said display screen;

wherein the flat aperture plate is configured such that the open apertures scan the flat

aperture plate in two-dimensional movements to generate an illusion that the opaque areas are transparent; and

a gap separating said display screen and said aperture plate, said gap being within a range of 0.1cm – 5cm;

wherein the three dimensional display simultaneously provides multiple different viewable perspectives of a scene based on horizontal and vertical viewing angles with respect to an open aperture.

77. (Original) The three dimensional display device according to claim 76, wherein said hybrid screen display comprises a high speed video projector and a display screen.

78. (Previously presented) The three dimensional display device according to claim 76, wherein the horizontal viewing angles comprise a horizontal view angle range of 20 – 60 degrees.

79. (Previously presented) The three dimensional display device according to claim 76, wherein said horizontal viewing angles has a viewable operating range up to 180 degrees.

80. (Previously presented) The three dimensional display device according to claim 76, wherein said vertical viewing angles comprise a vertical view angle range of 10 – 50 degrees.

81. (Previously presented) The three dimensional display device according to claim 76, wherein said vertical viewing angles have a viewable operating range up to 180 degrees.

9. RELATED EVIDENCE APPENDIX

Exhibit A, U.S. Patent No. 5,790,217 to Lee et al. (1998) was referenced on p. 19, paragraph 2 in the Response to the Final Office Action dated August 28, 2008, which was entered in the record on October 27, 2008.

10. <u>RELATED PROCEEDINGS APPENDIX</u>

None

EXHIBIT A

U.S. PATENT NO. 5,790,217

LEE et al.

US005790217A

United States Patent [19]

Lee et al.

[11] Patent Number: 5,790,217

[45] Date of Patent: Aug. 4, 1998

[54] **POLYMER-DISPERSED FERROELECTRIC LIQUID CRYSTAL DISPLAY**

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[73] Assignee: **Orion Electric Co., Ltd.**, Gumi, Rep. of Korea

[21] Appl. No.: **619,635**

[22] PCT Filed: **Aug. 5, 1994**

[86] PCT No.: **PCT/KR94/00106**

§ 371 Date: **Jun. 24, 1996**

§ 102(e) Date: **Jun. 24, 1996**

[87] PCT Pub. No.: **WO96/04586**

PCT Pub. Date: **Feb. 15, 1996**

[51] **Int. Cl.**[6] **G02F 1/1333**

[52] **U.S. Cl.** **349/86**; 349/92; 349/93

[58] **Field of Search** 349/86, 93, 92

[56] **References Cited**

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Primary Examiner—Anita Pellman Gross

Attorney, Agent, or Firm—Jacobson, Price, Holman & Stern, PLLC

[57] **ABSTRACT**

The present invention discloses a novel Polymer-Dispersed Ferroelectric Liquid Crystal Display (PDF LCD). The active matrix LCD such as a TFT LCD, the solution of low response speed of nematic LCD, requires very high production costs. The FLCD utilizing ferroelectric liquid crystal exhibits highly rapid response speed, but results in an unstable structure, difficult fabrication, and incompetency of expressing gray scales. Meanwhile, the PD LCD exhibits a simple structure, wide viewing angle and high strength, but low contrast thereof disqualifies it for image displays. The present invention combines the PD LCD and FLCD, that is, droplets of ferroelectric liquid crystal are dispersed in a polymer matrix to include the merits and compensate for the shortcomings of each. As a result, there is provided a novel PDF LCD having very rapid response speed, resistance to external shock or heat, and high contrast. Moreover, the present PDF LCD does not exhibit bistable characteristics to be able to express gray scales, and thus it is suitable for fabricating large area color image displays.

17 Claims, 2 Drawing Sheets

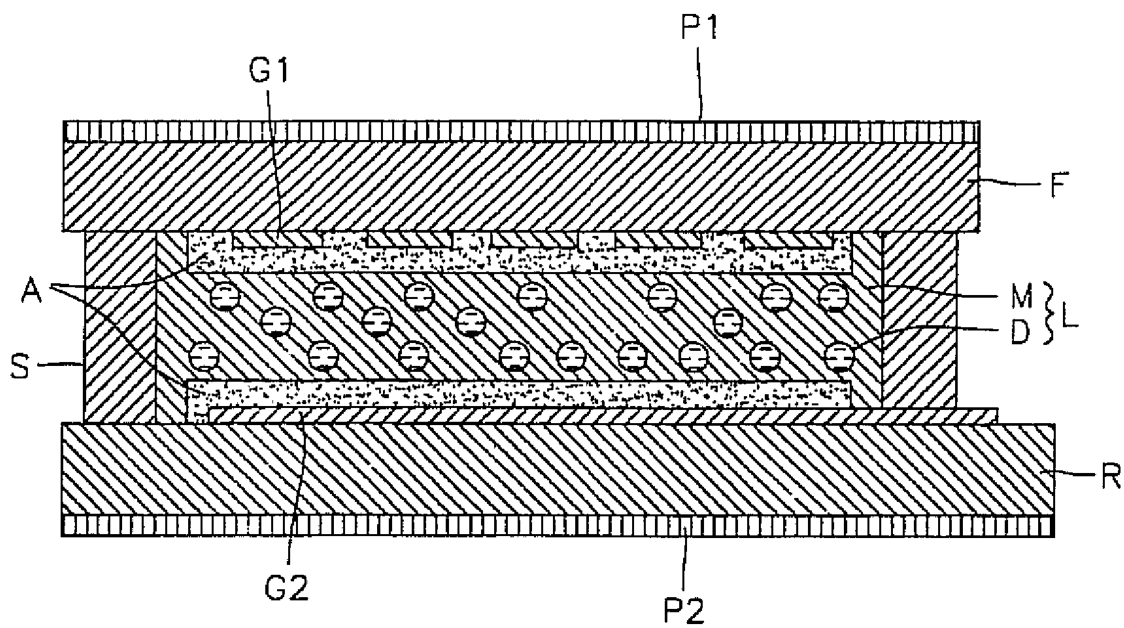


FIG. 1

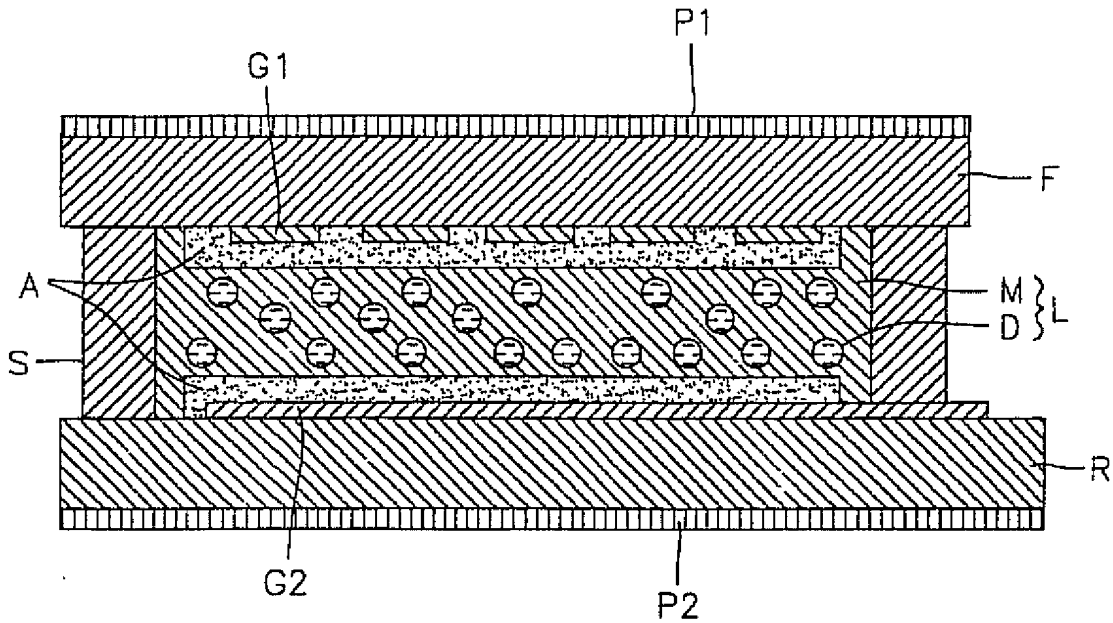

P1
G1
F
A
M
L
D
S
R
G2
P2

FIG. 2

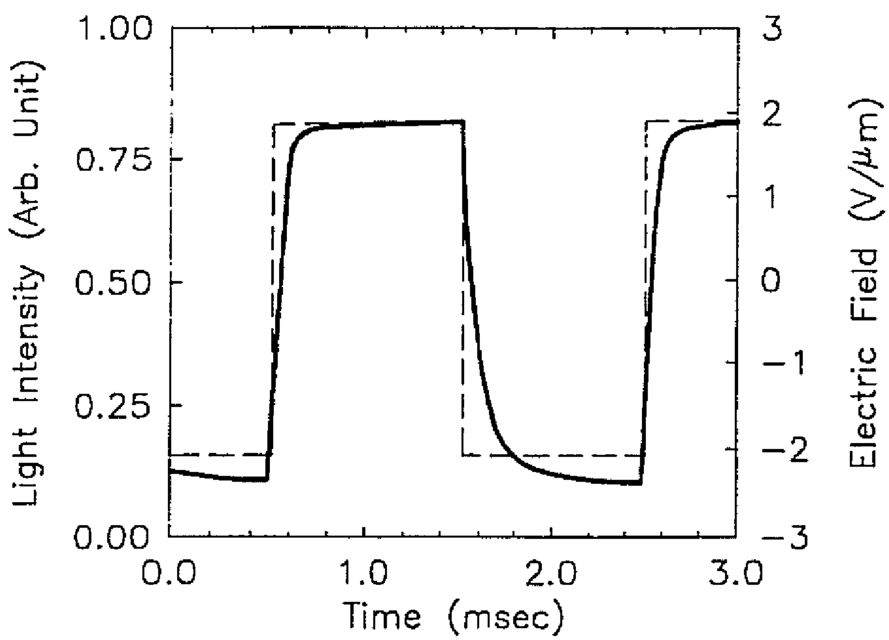

1.00
0.75
0.50
0.25
0.00
3
2
1
0
−1
−2
−3
0.0
1.0
2.0
3.0
Light Intensity (Arb. Unit)
Electric Field (V/μm)
Time (msec)

FIG. 3

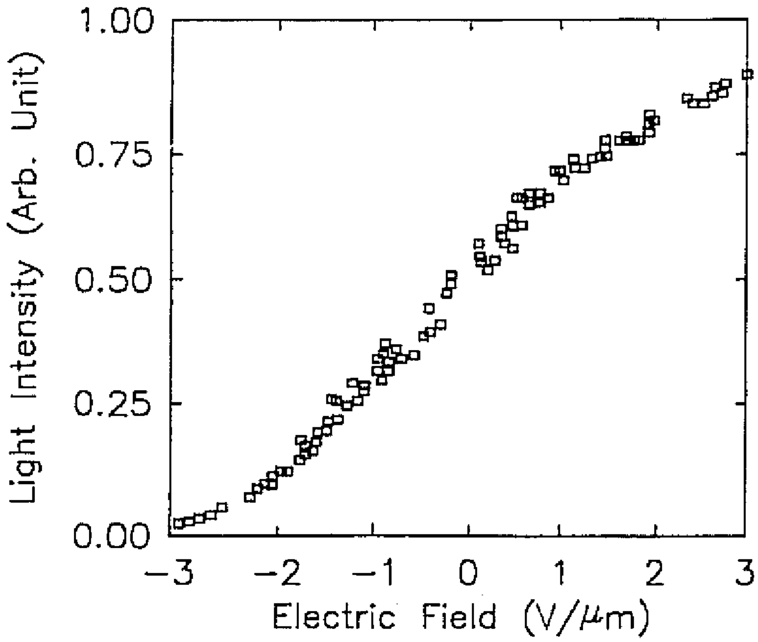
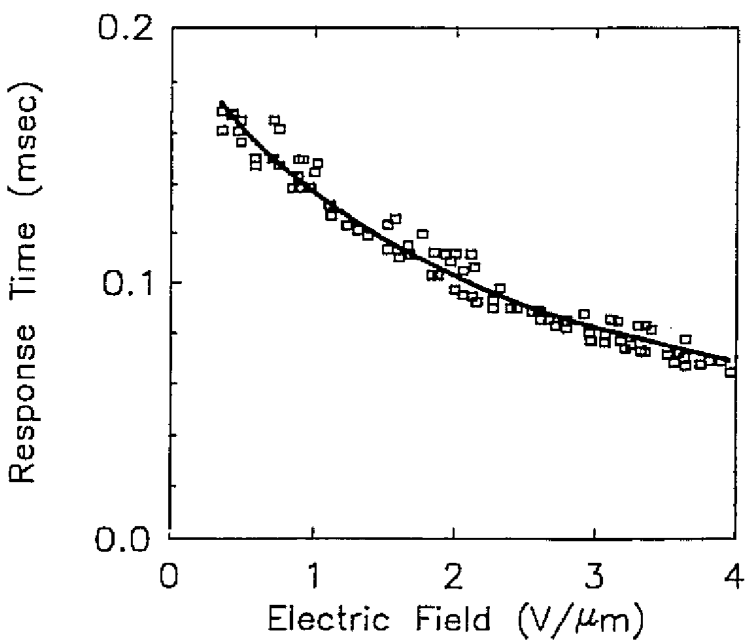

1.00
0.75
0.50
0.25
0.00
Light Intensity (Arb. Unit)
−3 −2 −1 0 1 2 3
Electric Field (V/μm)

FIG. 4


0.2
0.1
0.0
Response Time (msec)
0 1 2 3 4
Electric Field (V/μm)

POLYMER-DISPERSED FERROELECTRIC LIQUID CRYSTAL DISPLAY

TECHNICAL FIELD

The present invention relates to a liquid crystal display (LCD), and particularly to a novel LCD fabricated by dispersing ferroelectric liquid crystal(FLC) in a polymer matrix.

BACKGROUND ART

A Braun tube is generally adopted as the display for an image displaying apparatus such as a television. The Braun tube, however, has excessively large dimensions, and exhibits very high power consumption. Thus, the flat panel display(FDP) recently comes into wide use especially for the field of portable displays. Among these FDPs, the LCD is most widely used. The LCD is a typical non-emissive display utilizing electro-optic characteristics of a liquid crystal(LC), for example the dielectric anistropy.

Liquid crystals are divided into smectic, nematic and cholesteric phases according to their molecular structures. Among them, smectic and nematic LCs can be used for the purpose of display, but the smectic LC is not easily be aligned and the alignment is not stable under heat or shock. Most of practical LCDs, therefore, adopt nematic LCs.

As the nematic LCD, TN(Twisted Nematic) or STN (Super Twisted Nematic) LCDs have been used. TN or STN LCDs are constructed by aligning LC molecules to relatively twisted directions at upper and lower surfaces of the LC layer, and are already widely used. But, they cannot fulfill the rapid response speed and the viewability, such as a wide viewing angle, necessary for achieving the high resolution and a large screen. Accordingly, full-color or dynamic images cannot easily be achieved by these nematic LCDs. Moreover, they cannot be easily driven, as the optical response of simple matrix type nematic LCDs, depends upon the square of the applied voltage to result in little level difference between selected and non-selected pixels. As a result, the nematic LCD can only be applied to a portable television or a monitor of a notebook computer with unsatisfactory image quality. A TFT(Thin Film Transistor) LCD of an active matrix type has been developed, which enables a high speed action by independently switching each pixel by an array of driving elements. However, it has a highly complicated structure which results in high production cost and difficulty in fabricating a large screen.

All of the above described LCDs require the alignment of LC molecules in prescribed directions at boundary surfaces of the LC, and use separate polalizers to narrow the viewing angle and deteriorate the brightness. Thus, a Polymer-Dispersed (PD) LCD has been developed. It adopts the structure of dispersing submicron-sized nematic LC droplets in a polymer matrix. As the nematic LC has positive dielectric anistropy responding to the external electric field, it maintains an opaque state by scattering incident light when the electric field is not applied. When the electric field is applied, LC molecules of LC droplets are aligned in one direction to be a transparent state, and allow light to pass. As the PD LCD does not adopt an polarizer it results in a simple structure, a high brightness, and an wide viewing angle. Moreover, its polymer structure enables a flexible large LCD of a high strength at a low production cost. In the PD LCD, however, the driving voltage is applied to a LC through the polymer matrix, thereby revealing a high operating voltage, a large power consumption, and a low contrast. As a result, it can be utilized to control the lighting of a window, and not suitable for the image display such as a television.

All of above described LCDs utilize the dielectric anistropy of a LC, and the electro-optic characteristics thereof depend upon only the strength of applied voltage, regardless of its polarity. On the contrary, ferroelectric material is spontaneously polarized even if the electric field is not applied to exhibit a so-called bistable structure with two stable states. Recently, there has been reported that a smectic LC of a chiral-C phase exhibits ferroelectricty with a very high spontaneous polarization, and it has been adopted to a Ferroelectric LCD(FLCD).

In the FLCD, the direction of LC molecules is changed between two states without any alteration of the molecular structure, thus revealing a highly rapid response speed regardless of the viscosity of the LC. While the nematic LCD has the response speed of tens or hundreds of milliseconds (ms), the FLCD reveals much faster response speed of tens of microseconds (μs). Therefore, the FLCD overcomes the limit of the information content of the STN LCD, and reduces the production cost and, initial investment as compared with the TFT LCD.

But, the chiral-C phased smectic LC is not easily be aligned, and the alignment structure is easily changed by external shock or heat, thus resulting in low reliability.

Moreover, the thickness of the LC layer, namely the gap between two substrates should be reduced to prevent the spiral movement of the LC due to the chiral characteristic, and to align the LC in prescribed directions. Thus, the conventional FLCD forms the gap between substrates at 1 to 2 μm, and is referred to as Surface Stabilized (SS) FLCD. But it is very difficult to uniformly keep this small gap uniformly over the large area, thus the fabrication of a large FLCD, especially a SS FLCD, is practically impossible.

While the other voltage dependent LCDs can express gray scales by controlling the strength of the electric field, the FLCD is impossible to represent intrinsic gray scales, as the FLCD has only two states of aligned directions of LC molecules according to the polarity of the external electric field.

DISCLOSURE OF THE INVENTION

In consideration of the drawbacks of the above described various conventional LCDs, an object of the present invention is to provide a novel Polymer-Dispersed Ferroelectric Liquid Crystal Display(PDF LCD) having the advantage and compensating for the disadvantage of the PD LCD and the FLCD.

To achieve the above object, the PDF LCD according to the present invention, having two substrates opposed with a prescribed gap there between two grids respectively arranged on the substrates and being opposed to each other, and an LC layer in a cavity between the two substrates, characterized in that:

the LC layer is constructed by dispersing ferroelectric LC droplets in a polymer matrix.

According to one aspect of the present invention, the ferroelectric LC is smectic LC of chiral-C phase.

According to another aspect of the present invention, the LC located between the substrates is aligned in prescribed directions at each of its boundary surfaces, and is preferably aligned by rubbing an alignment layer.

According to other aspect of the present invention, means for polarizing, such as polarizers, are provided on substrates.

The resultant PDF LCD according to the present invention reveals a wide viewing angle and a high strength of a PD LCD, and the rapid response speed of an FLCD. The PDF LCD overcomes the drawback of the PD LCD thereby

providing a high contrast image, and resolve the alignment and gray scale problems of the FLCD, thereby providing a reliable alignment structure of stable characteristics, and make it possible to express intrinsic gray scales. The cell gap of the PD FLCD should not be formed as a small gap, as the SS FLCD, thus the fabrication of the PD FLCD becomes easy and thus a large LCD can easily be constructed. dr cl

BRIEF DESCRIPTION OF DRAWINGS

These and other objects and advantages of the present invention will be more apparent form the following detailed description, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic sectional view depicting the PDF LCD according to the present invention;

FIG. 2 is a graph showing the response of the PDF LCD to a square wave;

FIG. 3 is a graph illustrating the change of electro-optic characteristics of the PDF LCD with a change of applied voltage; and

FIG. 4 is a graph showing the response speed of the PDF LCD according to the present invention.

Referring to FIG. 1, a PDF LCD according to the present invention comprises an LC layer L formed by dispersing LC droplets D in a polymer matrix M, in a cavity, or cell gap, between front and rear substrates F, R. This structure is basically similar to that of PD LCD. The LC to form the LC droplets, however, is ferroelectric LC exhibiting the spontaneous polarization, in the present invention. The ferroelectric LC is smectic LC of chiral-C phase, for example. The present LCD requires an alignment structure to utilize electro-optic characteristics of ferroelectric LC, compared with the PD LCD using the scattering mode.

On inner surfaces of two substrates F, R, grids G1, G2 are arranged in the form of a matrix, for applying voltage to select pixels, and they are preferably formed of transparent conductive material, such as ITO(Indium Tin Oxide).

Meanwhile, alignment layers A are respectively formed on grids G1, G2 to align LC molecules in the droplet D is prescribed directions. The layer A is used not only for aligning LC, but also for preventing direct inflow of current from grids G1, G2 to the LC molecules. The layer A can be formed of polyimide, which is generally used for aligning TN or STN LCDs, and other polymer or aligning means other than the alignment layer A can be adopted if necessary. The polyimide layer can stably align LC molecules in LC droplets D to a prescribed direction, after being rubbed in certain directions.

At outer surfaces of each of substrates F, R, polarizers P1, P2 are respectively attached for linearly polarizing the incident light in one direction, thereby allowing or blocking light. Thus, the optical black and white states are formed to express the information.

And remaining symbol S designates, the sealing wall. Though it is not depicted plainly, spacers of glass or synthetic resin are uniformly dispersed in the cell gap between two substrates F, R to maintain an even gap between the two substrates F, R

Now, procedures to fabricate a sample of the above described PDF LCD according to the present invention, will be described.

First, a test panel having a cell gap for filling with LC layer L, is prepared. The test panel is fabricated by coupling two substrates F, R with the sealing wall S, and each of substrates F, R, respectively, has grids G1, G2 and alignment layers A aligned in prescribed directions. In this example, the thickness of the cell gap, namely the thickness of the LC layer L is selected to be 9.6 μm.

Then, LC and polymer to form the LC layer L is mixed in a prescribed mixing ratio. If the amount of LC is excessive, LC droplets D and polymer matrix M cannot be completely separated in the phase separation, while the electro-optic characteristics are deteriorated in the defficient case. Accordingly, the selection of an appropriate mixing ratio is very important. In the example, CS 2004 (trade name) of Chisso is adopted as chiral-C phase smectic LC, and NOA61 UV(Ultra Violet) curable polymer is adopted as polymer. According to the present inventor's tests, the range of 1:1.5 to 1:10 in weight seems to be appropriate for the mixing ratio of LC to polymer, and LC and polymer are mixed in the weight ratio of 1:3 in the example.

After that, the mixture of LC droplets and polymer is injected in the cell gap of the test panel. The temperature at the point of the injection, is preferred to be relatively high for preventing the separation of the mixture and resultant stain, due to the viscosity difference between LC droplets and polymer. The temperature at the point of the injection is preferred to be around the phase transition temperature at which LC molecules are changed from the LC phase to the isotropic liquid phase, and the temperature is selected to be 120° C. in the example.

If UV light is applied immediately after the injection of the mixture, the mixture is cured before the flow is stabilized. Thus, the mixture is kept still for a prescribed time at the above described temperature. In the example, the mixture is kept under the phase transition temperature of the LC molecules for example 120° C., for ten minutes. According to the present inventor's tests, LC droplets and polymer will not be uniformly mixed but separated, if the keeping temperature is low, while the effect of the alignment is reduced if high. Thus, the selected keeping temperature corresponds to the lowest temperature which allows the two materials to uniformly mixed.

Then, LC droplets and polymer phase separated by radiating with Uv light. In the phase separation, higher ambient temperature or higher radiation intensity of UV light accelerates the curing speed to reduce the size of the LC droplet D. Therefore, the size of the LC droplet D can be adjusted by controlling ambient conditions as described above. According to the present inventors tests, appropriate optical characteristics are obtained when the diameter of the LC droplet D is in the range of 0.5 μm to 10 μm. In that case, the gap between two substrates F, R, namely the thickness of the LC layer L or the cell gap, is preferred to be the value at which LC droplets D are adequately dispersed in the cured polymer matrix M, for example, in the range of 2 μm to 10 μm.

Meanwhile, two polarizers P1, P2 are respectively attached to each outer surface of substrates F, R, and attached angles thereof will be determined by the angle at which an optimum contast can be obtained according as the tilt angle of the LC. In the example, one polarizer, P1, is attached at the angle of 22.5°, and the other polarizer, P2, perpendicular with respect thereto.

Electro-optic characteristics of the example of the PDF LCD fabricated as described above, will now be described with reference to FIG. 2 to FIG. 4.

Referring to FIG. 2, there is shown the electro-optic response of the present LCD, when the pulse of a square wave formed voltage of 500 Hz is applied to the example. As shown in the drawing, the PDF LCD according to the present invention responds very well to a change of the external electric filled. Thus, the PDF LCD can be used for electro-optic display elements.

FIG. 3 illustrates the intensity of light after passing through two polarizers P1, P2 when the voltage of the squre

wave is varied. As shown in the drawing, the PDF LCD according to the present invention responds linearly at the low voltage, and is smoothly saturated as the voltage increases. In other words, the PDF LCD according to the present invention does not reveal the bistable characteristics of the SS FLCD, but exhibits continuous light passing characteristics according to the change of the external applied voltage. Therefore, the expression of intrinsic gray scales can be achieved by changing the applied voltage.

Referring to FIG. 4, there is shown the response speed of the present LCD according as the change of the external electric field. As shown in the drawing, the PDF LCD according to the present invention exhibits a response speed of about 0.1 ms, i.e. 100 μs. The PDF LCD is relatively slower than the FLCD which exhibits the response speed of tens of μs, but is much faster than the nematic LCD revealing tens of ms.

As described above, the present invention combines the PD LCD and FLCD to compensate merits and shortcomings of each of them. But the present PDF LCD reveals novel electro-optic characteristics which cannot be anticipated from a simple combination of the PD LCD and the FLCD.

Thus, the PDF LCD according to the present invention, exhibits a rapid response and high contrast as in the conventional FLCD, and remedies drawbacks of the FLCD to get a stable alignment and to express gray scales. And the thickness of the cell gap may not be formed in small as the SS FLCD, thus a large LCD can be easily fabricated.

Moreover, the PDF LCD according to the present invention has an excellent strength as in the PD LCD, thus a strong LCD resistant to external shock or impact can be fabricated. And its wide viewing angle also exhibits an excellent viewability.

Especially, the present PDF LCD exhibits the rapid response speed without any active matrix drive as in the TFT LCD, thus excludes the necessity of any active elements to drastically reduce production costs.

INDUSTRIAL APPLICABILITY

These various characteristics of the present PDF LCD will be suitable for displaying color images on a large screen, thus the present invention facilitates the fabrication of large area color display, such as a high definition television.

We claim:

1. A polymer dispersed ferroelectric liquid crystal display (PDF LCD) comprising a first and a second substrate arranged opposite each other with a prescribed gap therebetween, a first and a second grid arranged on said substrates opposed to each other, respectively, a first and a second alignment layer formed on said grids, respectively, and a liquid crystal layer in a cavity between said two substrates,

wherein said liquid crystal layer comprises droplets of ferroelectric liquid crystal dispersed in a polymer matrix, and

a mixing ratio of said ferroelectric liquid crystal and said polymer is in a range of 1:1.15 to 1:10 in weight.

2. A PDF LCD according to claim 1, wherein said ferroelectric liquid crystal is a smectic liquid crystal of a chiral-C phase.

3. A PDF LCD according to claim 1, wherein said liquid crystal is aligned in prescribed directions, respectively, at two boundary surfaces of said liquid crystal layer.

4. A PDF LCD according to claim 1, wherein, each of alignment layers is formed by

coating polymer material on said grids and

rubbing said polymer coating.

5. A PDF LCD according to claim 4, wherein said polymer material to be rubbed is polyimide.

6. A PDF LCD according to claim 1, further comprising means for polarizing on said substrates.

7. A PDF LCD according to claim 6, wherein said means for polarizing are polarizers which linearly polarize incident light.

8. A PDF LCD according to claim 1, wherein the diameter of said

droplets in said polymer matrix is in the range of 0.5 μm to 10 μm.

9. A PDF LCD according to claim 1, wherein the thickness of said liquid crystal layer is in the range of 2 μm to 10 μm.

10. A method for manufacturing a polymer dispersed ferroelectric liquid crystal display, comprising the steps of:

forming a first substrate having a first grid on a surface thereof and providing a first alignment layer overlying the first grid;

forming a second substrate having a second grid on a surface thereof and providing a second alignment layer overlying the second grid;

coupling the first and second substrates with sealing walls such that the substrates are opposite to each other with a prescribed gap therebetween;

injecting a mixture of ferroelectric liquid crystal and polymer into the prescribed gap; and

phase separating the liquid crystal and polymer,

wherein a mixing ratio of said ferroelectric liquid crystal and said polymer is in a range of 1:1.15 to 1:10 in weight.

11. The method according to claim 10, wherein a temperature at the state of injecting said mixture, is about the phase transition temperature of said liquid crystal.

12. The method of according to claim 10, and

wherein said phase separation is performed by radiation of UV.

13. The method according to claim 10, wherein said ferroelectric liquid crystal is a smectic liquid crystal of a chiral-C phase.

14. The method according to claim 10, wherein the step of forming each of said first and second alignment layers comprises:

coating polymer material on the grids; and

rubbing the coated polymer material.

15. The method according to claim 14, wherein the polymer material is polyimide.

16. The method according to claim 10, wherein said mixture is kept for a prescribed time at a prescribed temperature after the injecting step.

17. The method according to claim 10, further comprising a step of attaching two polarizers to outer surfaces of the two substrates.

* * * * *